General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.

- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.

- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.

- This document is paginated as submitted by the original source.

- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

Produced by the NASA Center for Aerospace Information (CASI)

(NASA-CR-153374) RESEARCH IN SPACE SCIENCE AND TECHNOLOGY Semiannual Progress Report (Massachusetts Inst. of Tech.) 28 p HC A03/MF A01 CSCL 22A

N77-30143

Unclas
G3/12 46217

CENTER FOR SPACE RESEARCH

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SEP 1977
RECEIVED
NASA STI FACILITY
INPUT BRANCH

Semi-Annual Progress Report

to the

National Aeronautics and
Space Administration

under

Grant NGL 22-009-638

August 1977

Center for Space Research
Massachusetts Institute of Technology

Semi-Annual Progress Report

to the

National Aeronautics and Space Administration

under

Grant NGL 22-009-638

Research in Space Science and Technology

August 1976

Prepared by: L. E. Beckley

Approved by: J. F. McCarthy, Jr.

Center for Space Research

Massachusetts Institute of Technology

Semi-Annual Progress Report

to the

National Aeronautics and Space Administration

under

Grant NGL 22-009-638

Research in Space Science and Technology

August 1976

Prepared by: L. E. Beckley

Approved by: J. F. McCarthy, Jr.

Center for Space Research

Massachusetts Institute of Technology

TABLE OF CONTENTS

		Page No.
I.	FOREWORD	1
II.	INTRODUCTION	1
III.	ACTIVE PROGRAMS	6
	A. Shuttle Space Experiment Applications. .	6
	B. Design Studies of Large Space Structures	6
	C. New Concepts for Space Experiments	7
	1. Thin Metal Film Technology Verification	8
	2. Composite Material Deterioration . .	9
	3. Large Area, Wide Field of View X-Ray Imaging Burst Detector Experiment for LDEF Missions	9
	4. A Wide Field Camera for X-ray Bursts and Transients.	10
	5. A Very Large Area X-Ray Experiment on Spacelab 2	10
	6. A Reflectance Spectrometer Experiment on the Jupiter Orbiter/Probe 1981/82 Mission	11
	7. A Sensitive X-Ray Observatory for Use on Spacelab Missions	12
	8. A Very Long Baseline Interferometer Station on Spacelab 2.	13
	9. Plasma Science Experiment on the Jupiter Orbiter Probe 1981/82 Mission	14
	10. Exploratory Study of Atmospheric Modification by Space Borne Microwave Beams	14

Page No.

11. Preliminary Design and Development of a Reflectance Spectrometer Instrument for Possible Mars Orbiter and Comet Missions 15

12. Participation in the Investigative Definition and the Development of a Field Acquisition Camera for the Faint Object Spectrograph on the Space Telescope. 16

13. Solar Wind Plasma Experiment on the NASA/ESA Out-of-the-Ecliptic Mission 17

D. Research in Space Structures. 18

E. Space Research Management 19

F. Exploratory Development of a Field Acquisition Camera for Faint Object Spectroscopy. 19

IV. PERSONNEL ON CENTER FOR SPACE RESEARCH PROGRAMS. 22

FIGURE 1 - Center for Space Research Space Missions 3

I. FOREWORD

This progress report is the second in a more formal documentation of progress achieved on research activities at the Center for Space Research under sponsorship of NASA Grant NGL 22-009-638. Earlier progress reporting was covered under NASA Scientific Information Exchange (SIE) reports.

Grant NGL 22-009-638 was initiated in March 1972 at the Center for Space Research as a substitute source of basic research funds in space science and technology, replacing the Sustaining University Grant (NGL 22-009-019) which began in 1963. The continued availability of these more flexible basic research and exploratory development funds has been an indispensable factor in maintaining a space flight hardware development capability at the Center for Space Research, M.I.T. Also, this support has contributed to the planning of many new and significant programs of space research resulting in successful space missions for other participants as well as M.I.T.

II. INTRODUCTION

Over the past year the principal research activity has been concentrated in the X-ray astronomy and interplanetary plasma Physics disciplines. However, a conscious effort has also been made to expand the science and technology base of the Center's involvement in new areas of infrared astronomy,

long base line interferometry, geological spectroscopy, space life science experiments, atmospheric physics and space based materials and structures research.

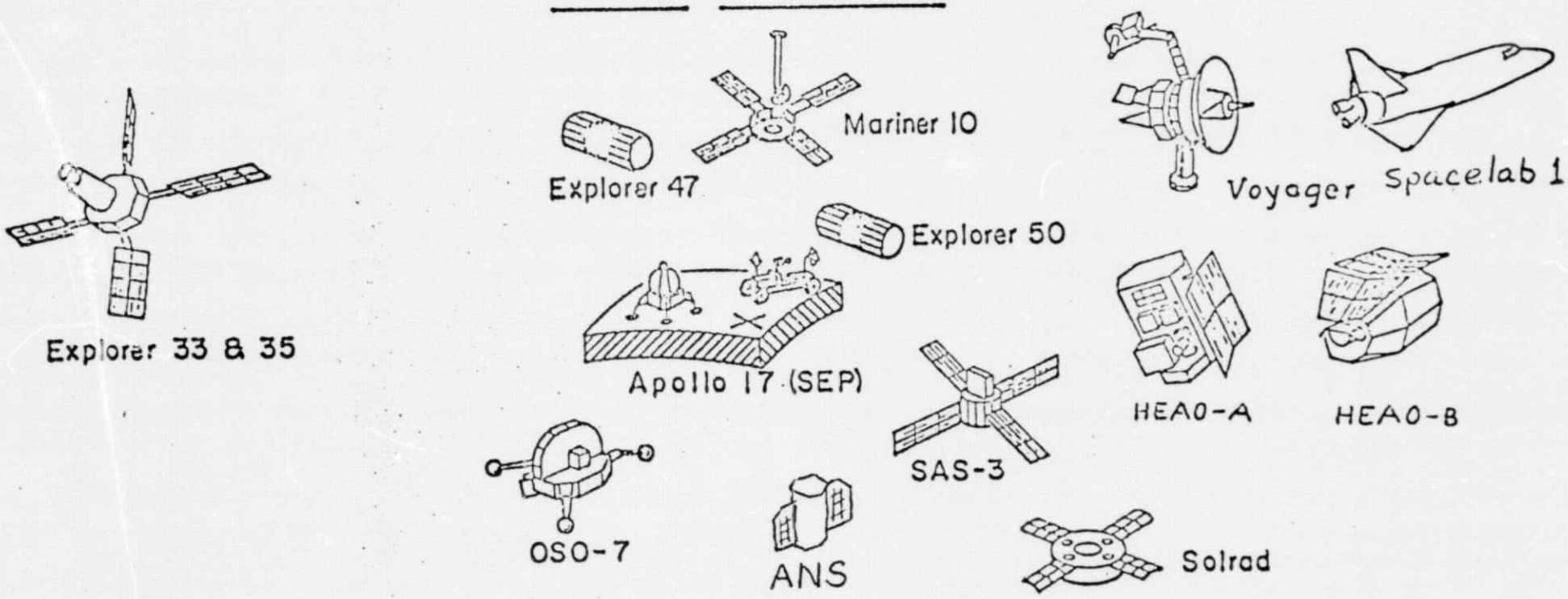
The Small Astronomy Satellite (SAS-3) continues to produce extremely important, new galactic and extra-galactic X-ray data since its launch in May 1975. This has required extensive upgrading of computational facilities within the Center to cope with this now third year extension beyond the originally planned one year of space data production. In addition, the recent launch of HEAO-A is expected to add significantly to the quantity and quality of new X-ray data which is resulting in unprecedented advances in man's knowledge about the universe.

Interplanetary plasma data is also currently being analyzed from Mariner 10 (launched in 1973), Explorers 47 and 50 (launched in 1973 and 1974), and Solrad (launched in 1976). A new dual launch of Voyagers 1 and 2 (launched August 20 and September 5, 1977) are returning excellent data on the plasma conditions beyond the orbit of Earth.

Figure 1 graphically illustrates the frequency and scope of these efforts along with the other space flight programs of the Center.

NASA Grant NGL 22-009-638 has provided an especially valuable resource during the past year with the continuing

CENTER FOR SPACE RESEARCH
SPACE MISSIONS



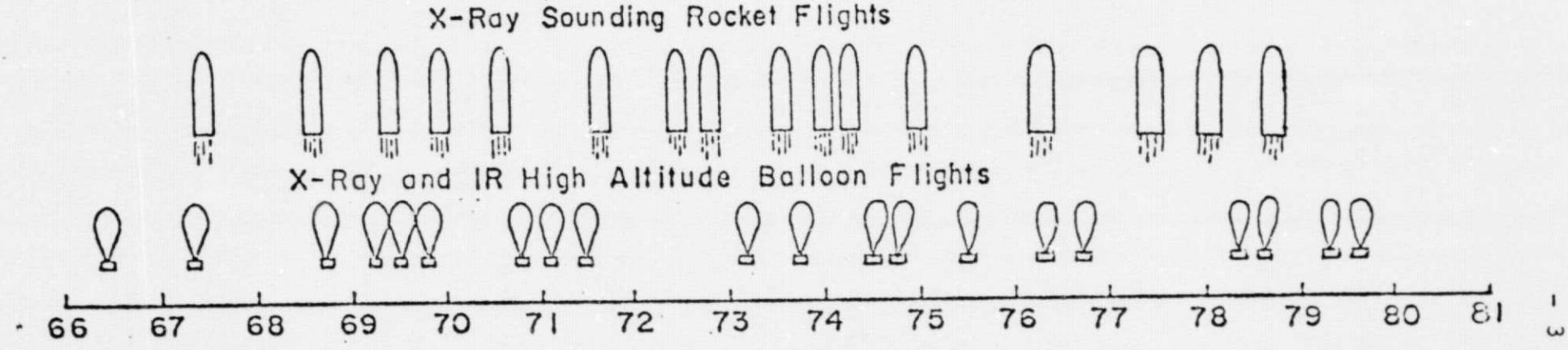


FIGURE 1

transition from the more frequent Explorer type space science missions of the early 1970's and the larger interplanetary and shuttle based missions of the present and immediate future. Except for sounding rocket and balloon flights, nearly three years elapsed between the last new Center for Space Research space science experiment start (the HEAO-B experiment was initiated in June 1974) and the recently initiated Spacelab 1 vestibular experiment which started in April 1977.

During the interim, a vigorous program of exploratory research and space mission definition effort has been engaged in by the Center. The August 1976 semi-annual report described some 10 new space experiment proposals that were developed and submitted to NASA during the 1975-76 year. Since August 1976, 13 additional space experiment proposals have been finalized and formally submitted to NASA for consideration. NASA grant NGL 22-009-638 provided a primary source of interim funding support for these extensive efforts.

Over the past year, the Center's ability for maintaining a critical level of hardware capability was further compromised with the completion and delivery of the HEAO-B, X-ray and Voyager plasma experiments. This has left only the Spacelab 1 vestibular experiment (currently only in program definition), a modest Air Force supported space structure research effort, and sounding rocket and balloon X-ray payload refurbishments as

active programs in the Center's Laboratory for Space Experiments. Even with the supplemental funds added to NGL 22-009-638 in February 1977, the combined support will not be sufficient to maintain the desired critical level of manpower for in-house hardware development. One to two new program starts are necessary as a minimum in the very near future to prevent the near total loss of this vital capability in the Center for Space Research. The ability and willingness of independent groups such as the Center to continue to develop important new space payload concepts depends heavily on the return on invested time and effort expended on new and imaginative space experiments proposals.

III. ACTIVE PROGRAMS

A. Shuttle Space Experiment Applications

M.I.T.-CSR Research Account: 81418

Period: September 1, 1973 to February 28, 1978

Principal Investigator: J. F. McCarthy, Jr., Professor of Aeronautics and Astronautics and Director, Center for Space Research

This project was established for exploratory studies within the expanded spectrum of new space experiments made possible by use of the Shuttle-Spacelab orbiting system. Discussions and workshops were held at M.I.T. to acquaint both new and experienced investigators with the special qualities and potential of the shuttle-spacelab mode of space experimentation.

During the past year a limited number of inquiries were received from potential M.I.T. investigators. However the major effort in this regard has now shifted to response to specific announcements of Spacelab research opportunities. Specific proposals have been in part supported under Account 83204, and are reported upon elsewhere in this progress report. Conceptual studies of new experiments have been supported as appropriate under the 81418 account.

B. Design Studies of Large Space Structures

M.I.T.-CSR Research Account: 82165

Period: July 1, 1974 to February 28, 1978

Principal Investigator: J. F. McCarthy, Jr., Professor of Aeronautics and Astronautics and Director, Center for Space Research

This project was established for exploratory studies in the use of composite materials in representative space structures. Primary attention was to be given to graphite-epoxy materials used in support structures between a spacecraft and a large

microwave antenna. Weight reductions of up to 50% and an order of magnitude reduction in thermal distortions were considered possible and represented design targets for the studies. Subsequently, a comprehensive proposal for a much larger design and fabrication project under prospective U.S. Air Force sponsorship was prepared and forwarded for consideration by the Air Force. The proposal was successful and resulted in a research-applications study which is now in progress.

Recently, the scope of this project has been expanded to include studies of alternate concepts that show promise for major overall system improvements for Satellite Solar Power Stations (SSPS) and other large space structures.

Over the past five years considerable interest has developed in the aerospace community in the concept of Satellite Solar Power Stations (SSPS) in geogynchronous orbit to provide baseload electrical power. Several design concepts have been studied for SSPS with 5 to 10 gigawatt capabilities. A practical SSPS design would provide significant relief of the nation's looming energy shortage. Unfortunately, the concepts proposed to date have been judged to be impractical because of the large capital costs involved and because of doubtful reliability for space-based operation (moving parts and cryogenics).

This study will investigate a new SSPS concept which may solve the capital cost and reliability problems. The new concept provides good structural stiffness and improved reliability and is obtained by complete elimination of moving parts in the design. The current study is a preliminary design effort aimed at sizing the SSPS and outlining key construction details. Consideration will also be given to the design of a smaller pilot-SSPS which could be flown as a Space Shuttle experiment to demonstrate the concept.

C. <u>New Concepts for Space Experiments</u>

M.I.T.-CSR Research Account: 83204

Period: July 1, 1975 to February 28, 1978

Principal Investigator: J. F. McCarthy, Jr., Professor of Aeronautics and Astronautics and Director, Center for Space Research

This project was established in recognition of the changing plans and priorities for space missions in the Shuttle-Spacelab

era. The development of imaginative new space experiments was undertaken in 1975 as reported upon in the August 1976 semi-annual progress report for NGL 22-009-638. Ten new space experiments were described.

During the past year 13 additional new space experiments have been developed to the proposal stage. These new experiments cover a wide range of disciplines including the behavior of materials in space, X-ray astronomy, measurement of the solar wind, Mars and Jupiter reflectance spectroscopy, very long baseline interferometry, atmospheric modification by microwave beams and faint object photography. The listing of proposals which follows does not include all proposals for space science and technology made by the Center for Space Research during the past year. However, it does include those for which a direct contribution was made from the resources available to the Center by NASA Grant NGL 22-009-638.

1. Thin Metal Film Technology Verification

Principal Investigator: Robert M. Rose, Professor of Materials Science and Engineering, M.I.T.

November 1976

The proposed experiment would be conducted on the Long Duration Exposure Facility (LDEF) to be put into Earth orbit by the Space Shuttle. This would be a technology verification experiment, exploring the utilization of thin (200-300 Å) substrateless metal (aluminum, gold and nickel) films under long exposure to the space environment. The objective would be to characterize optical, mechanical and chemical properties of samples of the films before and after exposure.

If the film properties remain stable, as reproduced in simulation experiments on the ground, these films would be suitable design points for use in future space vehicles and structures. If changes do occur, new science and/or technology will result. The changes, if any, may be minimized by variation of film deposition parameters in future tests.

2. Composite Material Deterioration

Principal Investigator: Frank A. McClintock, Professor of Mechanical Engineering, M.I.T.

November 1976

The objective of this experiment would be to develop data on graphite composite materials which have been subjected to prolonged exposure to the space environment. The end result would be characterization of the differences in modulus and tensile and fatigue strengths between the exposed samples and reference, unexposed samples.

Graphite samples, though offering generally superior mechanical properties, have some risks involved with their use in large space structures due to the lack of a data base relating laboratory-measured mechanical properties to post-environmental, end-use mechanical properties. This experiment would contribute substantially to forming that data base.

3. Large Area, Wide Field of View X-Ray Imaging Burst Detector Experiment for LDEF Missions

Principal Investigator: Walter H. G. Lewin, Professor of Physics, M.I.T.

Co-Principal Investigator: Kenneth A. Pounds, Professor of Physics, University of Leicester, England

November 1976

The objective of this study is to evaluate a wide field, high sensitivity X-ray burst and transient source detector for the LDEF. The instrument would be capable of locating bright bursts (and fast X-ray transients) to an accuracy limited by the LDEF angular rates (source locations to $\simeq$20 arc seconds for .001^{o}/s LDEF rates). In one LDEF mission, we might expect to observe $\simeq$100-1000 burst and fast transient sources in an all sky survey complete to a limiting sensitivity of $\simeq 10^{-1}$ crab seconds.

The LDEF experiment to be defined in this study should provide essential scientific information for the understanding of recently discovered classes of highly variable

X-ray emitters: the X-ray burst sources (Lewin 1976), the flare-like sources (Belian 1976), and the fast transient sources (Pounds 1976). The experiment will be based on a new wide field X-ray imaging system suggested by Ricker (1976). In addition, the appropriateness of LDEF as a platform for experiments requiring good stability (but no additional pointing system) will be established.

4. A Wide Field Camera for X-Ray Bursts and Transients

Principal Investigator: Walter H. G. Lewin, Professor of Physics, M.I.T.

Co-Principal Investigator: Kenneth A. Pounds, Professor of Physics, University of Leicester, England

November 1976

This proposal was in response to NASA Announcement of Opportunity AO-OSS-2-76. M.I.T., in collaboration with the University of Leicester, would design and construct a new type instrument for detecting X-ray bursts and transient sources. The instrument would be suitable for flights on Spacelab II and other future Shuttle missions. It was postulated that during a one-week Spacelab flight hundreds of new X-ray bursts, flare and transient sources could be located and studied with adequate spectral and temporal resolution such that optical and radio counterparts could also be identified through coordinated ground-based observations. It was estimated that the location of bright sources could be measured with the new instrument to an accuracy of ≈20 arc seconds and ≈1 arc minute for fainter sources over a range of 2-60 keV with 16 channel spectral resolution and 250 μ sec time resolution.

5. A Very Large Area X-Ray Experiment on Spacelab 2

Principal Investigator: George W. Clark, Professor of Physics, M.I.T.

November 1976

This proposal was in response to NASA Announcement of Opportunity AO-OSS-2-76. The objective of this experiment was to carry out a detailed study of the process involved in the generation of X-rays by high-luminosity, compact X-ray

sources through the precise measurement of rapid intensity and spectral variations of selected sources radiating in the 1.5 to 15 keV range.

The proposed instrumentation would be new and designed to take advantage of the larger instrument payload capacity of Spacelab. The proposed detector module would consist of a $2^{o} \times 2^{o}$ FWHM tubular collimator coupled with a flow proportional counter having wire walls, plastic film window, and a gross frontal area of 3,000 cm^2. The experiment would employ four detector banks, with eight coaligned detector modules in each bank, with overlapping fields of view. The total open window area of the four banks would be 4×10^4 cm^2. Pulses would be counted in four energy channels from 1.5 to 15 keV with accumulation times of 16 microseconds. The proposed observational program and procedures would be consistent with the pointing and maneuver capabilities of Spacelab 2. Aspect data for accurate post-flight attitude determinations would be obtained by conventional star photography. The accumulated data would consist of X-ray intensity records with time resolutions of 16 microseconds that would show periodic and non-periodic variations with unprecedented sensitivity. The instrument could be flown on subsequent Spacelab missions at only a nominal refurbishment cost.

6. A Reflectance Spectrometer Experiment on the Jupiter Orbiter/Probe 1981/82 Mission

Principal Investigator: Thomas B. McCord,
Professor, Institute for Astronomy,
University of Hawaii, and
Senior Research Associate, M.I.T.

December 1976

This proposal was submitted in response to NASA Announcement of Opportunity AO-OSS-3-76 by an investigative team of co-investigators from the University of Hawaii, the University of Washington, the Jet Propulsion Laboratory and M.I.T.

The primary objectives of the experiment would be to determine the mineralogic compositions of the non-icy portions of the surfaces of the Galilean Satellites, to map the distribution of water ice on the surfaces of J2 Europa and J3 Ganymede and to search elsewhere for its presence in the Jovian satellite system. Other objectives would be to determine the thermal

energy balance of individual regions of Jupiter by mapping the planet's spectral Bond albedo, and to determine the vertical structure of the Jovian atmosphere and its variation with time.

Measurement of the physical properties described above would be accomplished by a visible/near-infrared reflectance spectrometer currently under development for NASA by M.I.T. for the Lunar Polar Orbiter Mission. The spectrometer would measure light intensity in approximately 260 channels spread nearly linearly in energy space between 0.35 and 4.5 μm. Intensity precision would be between 0.1 and 2.0% at spectral resolutions between 5 and 80 nm.

7. A Sensitive X-Ray Observatory for Use on Spacelab Missions

Principal Investigator: Walter H. G. Lewin,
Professor of Physics, M.I.T.

November 1976

This proposed experiment was submitted in response to NASA Announcement of Opportunity AO-OSS-2-76. The proposal was a collaborative effort shared by the Center for Space Research, M.I.T.; the Cosmic Ray Working Group, University of Leiden, the Netherlands; the Max Planck Institute, Germany; and the University of Leicester, England.

The experiment would comprise a sensitive, wide energy X-ray observatory to be flown on Spacelab 2 and/or future Shuttle missions. The X-ray observatory would consist of three instruments: a low energy telescope, a medium energy instrument, and a high energy instrument - which together would cover the energy range 0.15 to 200 keV. The observatory would be capable of angular resolution of a few arc minutes and time resolution down to $\sim$ 10 μsec.

During a 10-day Spacelab mission it is estimated that approximately 5,000 sources could be located to an accuracy of a few arc minutes together with detection of spectral and temporal changes in the X-ray emission of $\sim$40 Seyfert galaxies and QSOs in the energy range of $\sim$1-200 keV, and detection of approximately 1,000 clusters of galaxies to a positional accuracy of a few arc minutes in the 0.15 to 2 keV range.

Corollary objectives would include detection of plasma instabilities in the magnetosphere of accreting neutron stars, changes in accretion flow due to turbulence and/or plasma instabilities around neutron stars and black holes, and X-ray pulsar mechanisms.

Where appropriate, coordinated optical, infrared, ultraviolet and radio ground-based observations would be carried out simultaneously with the proposed X-ray observations.

8. A Very Long Baseline Interferometer Station on Spacelab 2

Principal Investigator: Bernard F. Burke,
Professor of Physics, M.I.T.

December 1976

This experiment with a very-long-baseline interferometer (VLBI) station for the Spacelab 2 mission would be operated in conjunction with ground-based radio telescopes so as to generate a very large effective aperture providing angular resolutions of 0.0005 arc seconds and 0.002 arc seconds at wavelengths of 3.8 to 18 cm. respectively. Collaborating investigators would include Dr. Thomas A. Clark, Goddard Space Flight Center; Dr. Marshall H. Cohen, Department of Astronomy, C.I.T.; Dr. Kenneth I. Kellerman, National Radio Astronomy Observatory; Dr. James M. Moran, Smithsonian Astrophysical Observatory; Dr. Alan E. E. Rogers, Haystack Observatory, M.I.T.; and Dr. Irwin I. Shapiro, Department of Earth and Planetary Sciences, M.I.T.

The brightness distributions of quasars, active radio galaxies, and interstellar OH masers would be studied with the instrument to aid in the understanding of the physical processes occurring in these objects.

The proposed station would use components and techniques that already are used extensively in ground-based observations. The proposed Spacelab 2 experiment would be complete in its own right, and would be modular in design to facilitate upgrading of components for subsequent flights.

9. Plasma Science Experiment on the Jupiter Orbiter Probe 1981/82 Mission

Principal Investigator: Herbert S. Bridge, Professor of Physics, M.I.T.

December 1976

This proposed experiment represents a collaborative effort shared by Professor Bridge and others at the Center for Space Research, M.I.T.; Professors F. C. Michel and R. A. Wolf of the Department of Space Physics and Astronomy, Rice University; Professor George L. Siscoe, Department of Meteorology, University of California at Los Angeles; and Dr. Clayne Yeates of the Jet Propulsion Laboratory, C.I.T.

The goal of the experiment is the large-scale mapping of Jupiter's magnetosphere to enable the identification of the dynamical, atmospheric and satellite processes of importance in the various regions of the Jovian magnetosheath, magnetosphere and magnetotail. The fulfillment of these plasma science objectives, coupled with results from other particles and fields experiments, will permit the determination of the "stellar" parameters of Jupiter -- the rate of loss of mass, energy, angular momentum, and the rate of production of energetic particles.

The plasma instrument consists of three, split-collector Faraday cups. External and internal collimators modify the angular response of each half-collector so that the response is equivalent to six sensors, each with a conical response of 30^{o} full width at half maximum.

10. Exploratory Study of Atmospheric Modification by Space Borne Microwave Beams

Principal Investigator: John F. McCarthy, Jr., Professor of Aeronautics and Astronautics and Director, Center for Space Research, M.I.T.

January 1977

This proposal is for a joint study by the Smithsonian Astrophysical Observatory and the Center for Space Research, M.I.T., to determine the potential for utilizing high power microwave

energy, beamed from an orbiting platform, for active weather modification. CSR would perform the initial definition of system characteristics and performance parameters of the space system required to achieve the objectives determined during the analysis and simulation phases of the study program. The current concepts for Satellite Solar Power Systems (SSPS) would be considered as a source of energy in space to be converted to microwave energy for a 22.2 GHz weather modification beam.

11. Preliminary Design and Development of a Reflectance Spectrometer Instrument for Possible Mars Orbiter and Comet Missions

Principal Investigator: Thomas B. McCord, Professor, Institute for Astronomy, University of Hawaii
Senior Research Associate, Department of Earth and Planetary Sciences, M.I.T.

April 1977

The proposed instrument development for this project would be carried out in collaboration with Dr. John B. Adams, University of Washington; Dr. Michael J. Gaffey, University of Hawaii; Dr. James W. Head, Brown University; Dr. Robert L. Huguenin, University of Massachusetts; Dr. Terrence V. Johnson and Dr. Dennis Matson, Jet Propulsion Laboratory; and Dr. Carle Pieters, Johnson Space Center.

The objectives of the proposed program are to conduct the preliminary design and development of a visual/IR Reflectance Spectrometer Instrument (RSI) for possible Mars Orbiter and Comet Missions. Reflectance spectroscopy is a recognized scientific method for studying the surface chemical composition of the planets and other orbiting bodies of the inner solar system and the proposed instrument design would be able to perform a geochemical analysis of resolved surface regions of the Martian surface, cometary nucleus and optically thick regions of the coma and tail.

The proposal is for continuation of similar work under NASW-3008 for the period 1 November 1976 through 31 May 1977 which investigated RSI designs for various planetary orbiters. During this brief study the optical parameters were analyzed and several detectors and matched preamplifiers were evaluated.

During the twelve-month period beginning 1 June 1977 it is proposed to complete the analysis of the optical chain for the echelle-type spectrometer (0.35-4.5 microns) and construct a laboratory proof-of-concept breadboard utilizing a limited number of detectors to mechanically map the two-dimensional spectrum at the focal plane of the refocussing optics.

12. Participation in the Investigative Definition and the Development of a Field Acquisition Camera for the Faint Object Spectrograph on the Space Telescope

Principal Investigator: George W. Clark,
Professor of Physics, M.I.T.

June 1977

In response to the Announcement of Opportunity for Space Telescope, AO No. OSS-1-77, the University of Colorado has organized an Investigative Definition Team (IDT) for the development of a Faint Object Spectrograph (FOS) Instrument for the Space Telescope (ST). The proposal from the Massachusetts Institute of Technology (MIT) to the University of Colorado (CU) is for participation as a member of the IDT and for the development of the Field Acquisition Camera (FAC) portion of the FOS, and will be incorporated into the single joint proposal for the FOS being prepared by the University of Colorado. The Field Acquisition Camera is a CCD camera which facilitates target selection by the FOS by means of the direct imaging of the target field. Appropriate offset pointing corrections are computed and supplied to the spacecraft to position the subject target on the entrance slits of the spectrograph.

The MIT scientific participants will take a special interest in the use of the FOS to study problems in galactic and extragalactic astronomy related to the ongoing MIT work in X-ray astronomy. These participants will be particularly concerned, for example, with the study of X-ray binaries in the local group of galaxies, the cores of globular clusters, the nuclear structure of X-ray galaxies, and the properties of X-ray emitting clusters of galaxies.

MIT's scientific investigators are currently involved in the SAS-3 X-ray Satellite project and in the HEAO-A and HEAO-B projects. For the latter, the MIT group has developed the focal plane crystal spectrometer which will be used to study

the spectra of both compact and diffuse sources in the wave length range from 4 to 100 Å, where the emission of cosmic plasmas is expected to be rich in lines. Developments from this work will point toward specific correlative studies in the vacuum UV with the FOS.

The FAC, the development of which will be MIT's responsibility, has a substantial potential for use as a sensitive area photometer with an extremely large and linear dynamic range. It could be used to measure the brightness distributions in the central regions of globular clusters and galaxies, for example, and the fine detail of nebulosities. It could prove valuable as a backup photometer in the event of degradation or failure of the primary ST photometer. The MIT/CSR scientific participants will evaluate the scientific potential of the acquisition camera during the developmental phase, and will design it so as to achieve the maximum scientific utility consistent with its primary function as a supportive device for the FOS.

13. Solar Wind Plasma Experiment on the NASA/ESA Out-of-the-Ecliptic Mission

Principal Investigator: Herbert S. Bridge, Professor of Physics, M.I.T.

August 1977

This proposed experiment is a collaborative effort among plasma scientists at the Center for Space Research, M.I.T.; Dr. Keith W. Ogilvie and Dr. Jack D. Scudder of the Goddard Space Flight Center; Dr. Clayne Yeates of the Jet Propulsion Laboratory, C.I.T.; and Dr. Alberto Egidi and Dr. Giovanni Moreno of the Consiglio Nazionale delle Ricerche, Frascati, Italy.

The proposal describes a plasma experiment for the NASA/ESA Out-of-the-Ecliptic Mission (OOE) which can make three-dimensional electron and positive ion measurements throughout the proposed mission.

The proposed plasma instrument consists of two modulated-grid Faraday cup sensors for ion measurements and two curved plate electrostatic spectrometers for electron measurements. For ions, the voltage range is from 250 to 12,000 V and is covered by 96 contiguous windows with velocity resolution of

2%, full width. At Jupiter the range is biased down with 150 volts. For electrons, two energy ranges are used: 5 to 400 V and 50 to 4000 V. They are each covered by 24 windows. The analyzer energy resolution is 6%, full width. Two channeltron detectors of different sensitivities and acceptance angles are used in each analyzer.

Both electron and positive ion sensors make measurements over three distinct azimuthal sectors during one spacecraft rotation. The same set of energy steps is repeated in all three azimuthal sectors of a given spin. The full measurement requires 7 spin periods (or 84 seconds). These observations can be used to characterize the full three dimensional properties of both the electron and positive ion distribution functions. The bit rate is 32 bits per second for low spacecraft bit rates or 48 bits per second at higher spacecraft rates.

The proposed plasma observations on OOE are designed for the investigation of plasma phenomena in unexplored regions of the heliosphere, and have the potential for fundamental increases in our knowledge of interplanetary dynamical processes.

D. Research in Space Structures

M.I.T.-CSR Research Account: 84949

Period: March 1, 1977 to February 28, 1978

Principal Investigator: J. F. McCarthy, Jr., Professor of Aeronautics and Astronautics and Director, Center for Space Research

This project was established to support investigations of the applications of advanced composites to the design of space structures with the aim of minimizing thermal distortions during sun cycles, lowering weight while increasing stiffness and decreasing radio-frequency and electromagnetic interference. Cost, producibility and inspectability are to be considered in the design concepts.

Highly efficient structures for space antennas, solar collectors and other space applications represent a fundamental and needed technology in the near future. Significant cost savings are projected using the lighter weight composites in addition to their other benefits.

Joint support in this area of research is also being made available through contracts sponsored by the U.S. Air Force.

E. Space Research Management

M.I.T. CSR Research Account: 84987

Period: March 30, 1977 to February 28, 1978

Supervisor: J. F. McCarthy, Jr., Professor of Aeronautics and Astronautics and Director, Center for Space Research

This project was established on a transitional basis to assist with internal management costs within the Center for Space Research in the preparation of new proposals for research and related costs. A recent revision in the procedures whereby internal overhead costs within the Center are shared to a greater extent by the Institute has resulted in a reduction in overall internal costs within the Center but required as a side effect, the local absorption of part-time costs of some Center management personnel.

There is precedent for this handling of local administrative costs that goes back to the early years of the Center for Space Research when all local administrative costs of the Center were charged directly to the Sustaining University Grant.

However, it is expected that the shifting of local management responsibilities within the Center over the next year will provide the means for discontinuing these special costs to the basic grant.

F. Exploratory Development of a Field Acquisition Camera for Faint Object Spectroscopy

M.I.T.-CSR Research Account: 85518

Period: June 1, 1977 to February 28, 1978

Principal Investigator: George W. Clark
Professor of Physics, M.I.T.

This project was established to assist in the demonstration of proof-of-concept for the Charged Coupled Device (CCD) optical sensor as an integral element of a field acquisition camera for Faint Object Spectroscopy. A Faint Object Spectrograph is one of the important new instruments planned for use

on the 2.4 Meter Space Telescope tentatively scheduled for launch into Earth orbit in 1983.

CCDs have developed very rapidly in the photosensor field and show great promise in future optical, infrared and X-ray astronomy applications. They combine high quantum efficiency, wide dynamic and spectral ranges and unusual geometric and photometric stability.

The M.I.T. Center for Space Research has successfully adapted a CCD imager to a star tracker for high altitude balloon X-ray astronomy. Recently, the Center proposed in collaboration with investigators at the University of Colorado, the University of California and Princeton University, to develop a CCD-based field acquisition camera for the Space Telescope.

Other potentially attractive applications include the development of a point area photometer for faint object studies using the McGraw Hill Observatory 52-inch optical telescope and an area imager for the proposed 1.2 meter X-ray reflecting telescope planned for the HEAO (Block II) orbiting observatory. The McGraw Hill Observatory at Kitt Peak, Arizona, is operated jointly by the University of Michigan, Dartmouth College and the Massachusetts Institute of Technology.

The Charles Stark Draper Laboratories have been actively engaged in other CCD applications, and have agreed to cooperate with the Center for Space Research in facilitating the acquisition of sample CCD arrays of the most advanced type from the supplier, Texas Instruments, Incorporated. This new array combines a thinned, back side illuminated, buried channel structure with low noise levels and small pixel size. A special preamplifier, clocking and control electronics module, also manufactured by Texas Instruments, will be acquired with the samples. Appropriate authorization for approval to purchase the needed special test equipment has been requested from NASA.

A special CCD Research Laboratory is being established within the Space Center to include optical benches, a Nova computer and peripherals and other special, low light level research devices. The Center will utilize the advantages already gained in CCD research for X-ray astronomy applications by combining these laboratory facilities into a single entity. The Center's Laboratory for Space Experiments will collaborate by providing the design and fabrication of analog and digital circuitry for the CCD test facilities and Microprocessor-based

controllers with the capability for evolving into field-usable (optical) or flight prototype (optical and X-ray) units. LSE will also assist in the analysis and design of cooling systems.

With delivery of the new CCD arrays and associated equipment (expected prior to October 1, 1977) the Center will proceed immediately with measurements of spectral response and quantum efficiency of the new CCD sampler for optical photons and will make measurements of the dark noise pattern and its dependence on temperature for each of the CCDs. Measurements will also be made of the spectral response and quantum efficiency of the CCDs for X-ray photons. Finally, a field-usable microprocessor controller for the CCD array will be developed. With these developments field trials may then proceed to determine the full potential of the new field acquisition camera for Space Telescope and X-ray observatory applications.

IV. PERSONNEL ON CENTER FOR SPACE RESEARCH PROGRAMS
(As of July 1, 1977)

Faculty

J. W. Belcher, Ph.D.
H. V. Bradt, Ph.D.
K. Brecher, Ph.D.
H. S. Bridge, Ph.D.
B. F. Burke, Ph.D.
C. R. Canizares, Ph.D.
G. W. Clark, Ph.D.
P. C. Joss, Ph.D.
S. G. Kleinmann, Ph.D.
W. H. G. Lewin, Ph.D.
J. F. McCarthy, Jr., Ph.D.
P. Morrison, Ph.D.
S. Olbert, Ph.D.
C. M. Oman, Ph.D.
S. A. Rappaport, Ph.D.
B. B. Rossi, Ph.D.
R. J. Wurtman, M.D.
L. R. Young, Sc.D.

Senior Research Staff

J. H. Binsack, Ph.D.
H. T. Hermann, M.D.
A. J. Lazarus, Ph.D.
A. Natapoff, Ph.D.
O. Orringer, Sc.D.
A. D. Weiss, M.D.

Research Staff

L. H. Bannister, B.E.E.
E. A. Boughan, B.S.
R. J. Butler, B.S.
J. F. Donaghy, B.S.
R. E. Doxsey, Ph.D.
A. R. Ephrath, Ph.D.
R. F. Goeke, S.B.
G. S. Gordon, Jr., Ph.D.
D. R. Hearn, Ph.D.
J. A. Hoffman, Ph.D.
T. H. Markert, Ph.D.
A. Mavretic, Ph.D.
W. F. Mayer, Ph.D.
J. E. McClintock, Ph.D.
F. A. Primini, Ph.D.
J. A. Richardson, Ph.D.
G. R. Ricker, Ph.D.
J. D. Sullivan, Ph.D.
P. C. Tappan, B.S.
D. R. Tickle, B.A.
E. Y. Tsiang, Ph.D.
W. A. Wheaton, Ph.D.

Consultants

A. R. Ramsey, Ph.D.
G. L. Siscoe, Ph.D.
M. P. Ulmer, Ph.D.
P. F. Winkler, Ph.D.

Programming & Analysis Staff

B. C. Chiu, M.S.
W. M. Coertnik, B.S.
E. A. Johnston

Administrative Staff

L. E. Beckley, S.B.
D. W. Calileo'
H. L. Curtis, Jr., B.S.
J. B. Morway, B.S.
W. R. Shaw, B.S.
R. P. Webber, B.B.A.

Visiting Engineer

Y. Shiratori, B.S.

Visiting Scientists

K. Apparao, Ph.D.
G. Spada, Ph.D.

Support Personnel

Exempt	9
Office	14
Hourly	7

Graduate Students

17

Undergraduate Students

22